

**ROLE OF FETAL THIGH CIRCUMFERENCE IN
PREDICTION OF FETAL WEIGHT AND COMPARING
IT WITH OTHER CLINICAL AND ULTRASOUND
METHODS**

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CONTENTS

SL.NO	TOPIC	PAGE NO.
1	INTRODUCTION	1
2	AIM OF THE STUDY	4
3	ESTIMATION OF FETAL WEIGHT – MEASUREMENT OF PARAMETERS	5
4	REVIEW OF LITERATURE	16
5	MATERIALS AND METHODS	47
6.	RESULT	50
7.	DISCUSSION	53
8.	SUMMARY	72
9.	CONCLUSION	75
10.	BIBLIOGRAPHY	
11.	PROFORMA	
12.	MASTER CHART	

INTRODUCTION

Fetal and extra uterine life forms a continuum during which human growth and development are affected by genetic, socioeconomic and environmental factors. One of the most important factors among them is the BIRTH WEIGHT– An important determinant for neonatal survival.

The striking inverse relationship between birth weight and infant morbidity and mortality has been documented by several studies ⁽¹⁶⁾. The mortality is high especially in the neonatal period decreasing progressively till 3 years of age. Perinatal and Infant mortality rates are two times higher in Low Birth Infants.

World Health Organization (WHO) ⁽¹⁵⁾on the basis of world wide data has recommended that newborns with birth weight less than 2500grams may be considered to fall in low birth weight categories (LBW) carrying relatively greater risk of perinatal and neonatal morbidity and mortality with a substandard growth and development in later life. Nearly 80% neonatal deaths and 50% infant deaths occur among these groups. They are prone to develop

malnutrition, recurrent infection and neurodevelopmental handicaps. These low birth and growth retarded neonates are prone to develop Diabetes, Hypertension and Coronary Heart disease in later life. Hence low birth weight is a key factor for adverse outcome in later life. ⁽¹⁷⁾

In another end of spectrum are macrosomic fetuses which weigh more than 4000gms. The higher morbidity and mortality in them is due to association of maternal diabetes, prolonged labor, shoulder dystocia and higher incidence of caesarian section. These babies are susceptible to birth injuries like clavicle fractures, brachial plexus injuries, hypoglycemia, electrolyte imbalance and neonatal jaundice.

Estimation of birth weight assumes great significance during detection of intrauterine growth restriction and prevention of prematurity.

Estimated fetal weight is taken into consideration when making clinical decisions involving induction or delay of labor and deciding on the method of delivery.

Accurate EFW seems to be most important when dealing with high-risk populations, such as fetuses at risk for preterm delivery, fetuses that are small for gestational age (SGA), and macrosomic fetuses.

The error of sonographic EFW appears to be more at the two ends of the weight scale. With most EFW formulas, low BWs are overestimated, and high BWs are underestimated.

Hence there is a need for suitable formula for prediction of birth weight with good accuracy in fetuses of all weight categories.

With this background a study has been conducted to predict the fetal weight by adding one more parameter – mid thigh circumference for improving the accuracy of the available formula. This has been analyzed and compared with other available formula.

AIM OF THE STUDY

1. To evaluate the accuracy of predicting birth weight by various clinical and ultrasound methods and comparing it with actual neonatal weight.
2. Analyzing the accuracy of estimating the fetal weight by adding one more parameter – mid thigh circumference and comparing it with
 - the usual Hadlock formula
 - clinical methods of fetal weight estimation and
 - The actual neonatal weight.

ESTIMATION OF FETAL WEIGHT – Methods and Measurement

A lot of work has been done to find out accurate methods of estimation of fetal size and fetal weight in utero. They include

- Clinical estimation
- Ultrasound estimation

Clinical methods of estimating fetal weight

1. Johnson's Formula: ⁽¹⁹⁾

According to this formula Fetal weight in grams =
(Symphysiofundal height in cms – N) X 155.

Symphysiofundal height is calculated after correcting the dextrorotation of the uterus. The length is taken between the symphysis pubis and the fundus. The station of the presenting part is determined. If it is below the spines value of N is 11 and if the station of the presenting part is above the spines then N has a value of 12.

2. Insler's Formula: ⁽²⁰⁾

According to this formula Fetal weight in grams =
Symphysiofundal height in cms X Abdominal Girth in cms.
Abdominal girth is measured in cms at the level of the umbilicus.

Measurement of Parameters:

The patient was asked to empty her bladder. Symphyseal-fundal height (SFH) and abdominal girth (AG) was measured using a flexible, standard sewing tape.⁽⁵⁾ Both measurements were performed with the patient lying flat on her back, with her legs extended, and were rounded to the nearest centimeter. The fundal height was measured from the midpoint of the upper border of the pubic symphysis to the highest point of the uterine fundus. The upper hand was placed firmly against the top of the fundus with the measuring tape passing between the index and middle fingers and readings were taken from the perpendicular intersection of the tape with the fingers. For the AG measurement, the tape was repositioned to encircle the woman's waist, at the level of the umbilicus, without applying excessive pressure to tighten the tape around the abdomen.

A pelvic examination is done to evaluate cervical dilation and the degree of descent of the fetal head into the pelvis. The fetus was considered to be at a minus station when the lowermost portion of the fetal head was above the ischial spines, at zero station (engaged) when the vertex was at the level of the spines and at a plus station when it was below this level. Both measurements (SFH and AG) and information on the fetal station were recorded on the individual data sheet and later used to calculate the fetal weight according to the formulas proposed by Johnson and Insler.

Limitations in the estimation of Birth Weight by clinical methods:

Inaccurate measurements may be obtained in cases of

- thick or obese abdominal wall
- malpresentations like transverse lie
- polyhydramnios, oligohydramnios
- multiple pregnancies
- uterine or adnexal tumor complicating pregnancy
- Intrauterine growth restriction

Advantages:

- These formulas are very simple to use.
- It is applicable in places where Ultrasound is not available especially in a developing country like India.
- They can be used even by paramedical workers.

With advances in technology and computer processing, ULTRASOUND has become an essential tool in modern Obstetric practice. It is crucial for the assessment of various fetal, placental and liquor indices. It is also superior to clinical examination for determining fetal growth, gestational age and fetal weight.

Basic fetal measurements that are used to estimate various fetal parameters constitute FETAL BIOMETRY ⁽¹⁸⁾. The basic fetal parameters include Biparietal diameter, abdominal circumference and Femur length. Others include measuring Head circumference, Long bones (tibia, humerus), mid thigh circumference, mid arm circumference, intraorbital diameter and transcerebellar distance.

With training and practice, these measurements can be obtained with a high degree of consistency and accuracy.

Ultrasound Biometry:

Crucial decisions are made on the basis of fetal biometric measurement. Hence each clinician should be well schooled in obtaining these measurements by proper technique.

Biparietal Diameter (BPD):

Biparietal diameter is a two dimension measurement. Any plane of section through a 360 degree arc that passes through the Thalami and third ventricle is acceptable for measuring the BPD.

Rules for measuring Biparietal Diameter:

1. Correct plane of section through the Third ventricle and Thalami is taken.
2. Calvaria should be smooth and symmetric bilaterally.
3. Measurements are taken between

- I. Outer edge of near calvarial wall to inner edge of far calvarial wall
 - II. inner edge of near Calvaria wall to outer edge of far calvarial wall
 - III. Middle of near calvarial wall to middle of far calvarial wall.
4. Biparietal measurement is a measurement that can be obtained with great consistency and accuracy.

Femur Length (FL):

Femur length is a single dimension measurement. It is easy to measure. The transducer is aligned to the long axis of the diaphysis of the bone to obtain a proper plane of section. Only the ossified portions of the diaphysis and metaphysis are measured. Though the cartilaginous ends of the femur are demonstrated they are excluded. Proper alignment of the transducer to the long axis of the bone is ensured by demonstrating that both the femoral head or greater trochanter and the femoral condyle are simultaneously in the plane of section.

Rules for measuring Femur Length:

1. Align the transducer to the femur and freeze the plane that shows both the cartilaginous femoral head and distal condyle.
2. Place the measuring cursors at the junction of the cartilage and bone.

Abdominal Circumference (AC):

Abdominal circumference is a three dimensional measurement. The fetal abdominal circumference is measured at a position where the transverse diameter of the liver is the greatest. It is determined sonographically as the position where the right and left portal veins are continuous with one another.

Rules of measurement:

1. Correct cephalocaudal plane is selected at the confluence of right and left portal veins.
2. Appearance of lower rib is symmetric.

3. The shortest length of umbilical segment of the left portal vein is depicted. If a long segment is seen then transducer is erroneously angled inferiorly instead of being perpendicular.

Abdominal Circumference generally has the largest reported variability. Abdominal circumference is more acutely affected by growth disturbances than other parameters.

Mid thigh circumference:

Mid thigh circumference is a three dimension measurement. First whole length of femur from greater trochanter to the distal metaphysis was imaged.

Rules of measurement:

After the image of the thigh is imaged the transducer is rotated by 90degrees to obtain a cross sectional profile of the middle of the thigh at a position where

1. The bone profile is as round as possible
2. The boundary of the thigh profile is well defined.

Thigh circumference is determined with elliptical approximation three times and the average is taken as the final measurement.

After the basic parameters have been measured, estimation of Birth Weight is made. Various Formulae and Nomo grams are available for estimation of fetal weight using combinations of Biparietal diameter, Abdominal Circumference, Femur Length and mid thigh circumference.

Hadlock Formula: ⁽²¹⁾

Most of the modern ultrasound machines have computation package utilizing Hadlock formula for estimating fetal weight. It is calculated from three fetal parameters – Biparietal diameter, abdominal circumference and Femur length. This formula has a recommended error of less than 10%. According to this formula ¹⁸

$$\text{Log}_{10}\text{EFW}=1.335-0.0034(\text{AC})(\text{FL})+0.0316(\text{BPD}+0.0457(\text{AC})+0.1623(\text{FL})$$

Vintzileos Formula: ⁽²²⁾

This utilizes mid thigh circumference. Thigh circumference is one of the parameters that reflects soft tissue mass. It reflects directly upon the fetal nutritional status. Also it is easily measurable and reproducible. The measurement error is also small in the range of 4 %. This measurement is comparable with other fetal parameters in variability. This parameter is also useful in predicting the birth weight where fetal growth abnormalities are present.

According to this formula,

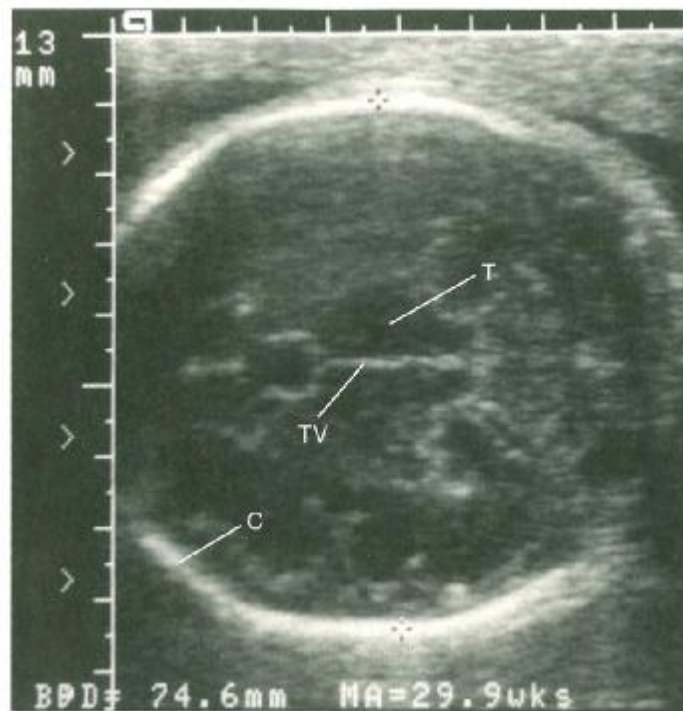
$$\text{Log}_{10} (\text{BW}) = 1.897 + (0.015 \times \text{AC}) + (0.057 \times \text{BPD}) + (0.054 \times \text{FL}) + (0.011 \times \text{TC})$$

Measurement of parameters:

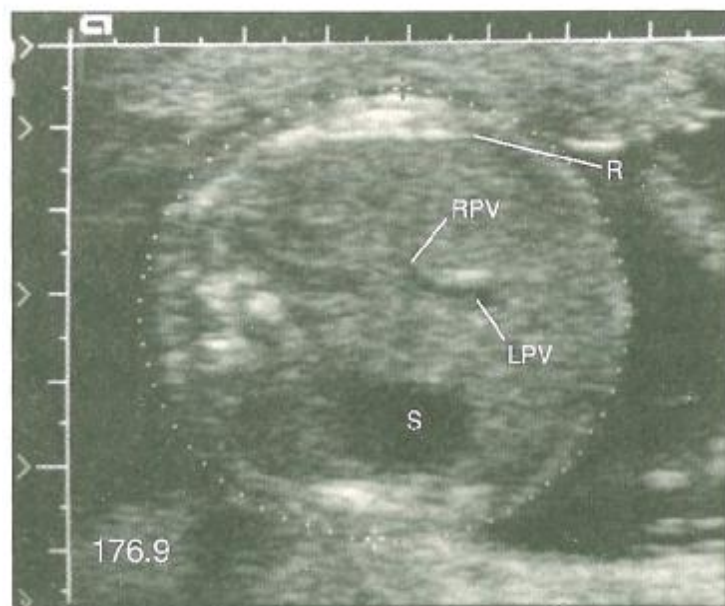
The patient was done an obstetric ultrasound scan that included electronic caliper measurement of the fetal head, abdomen and femur, as well as thigh circumference. The ultrasound fetal weight was calculated automatically by the equipment, using Hadlock's reference table, which used the Biparietal diameter,

abdominal circumference and femur length. All examinations were performed on the Mindray DigiPrince DP-6600 ultrasound equipment available in the Obstetric and Gynecology Department using a convex 3.5 MHz transducer.

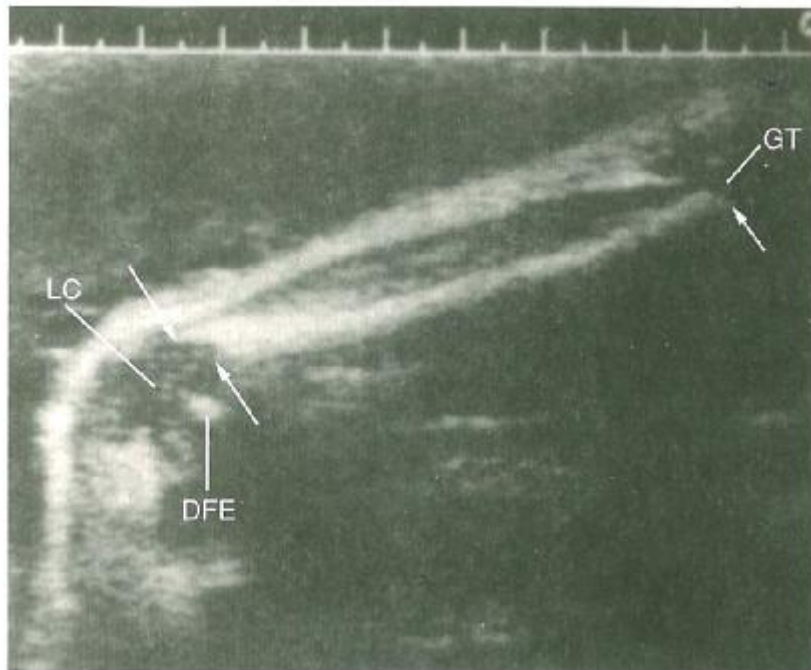
Potential errors in biometric measurements are numerous and can be engendered by equipment misregistration, aberrations of the transducer, type of transducers and most important of all is the experience of the sonologist who does the investigation. The instrument should also have accurate linear measurement. Biometric tables should be accurately entered in machine computation package. Also the plane of section and endpoint of measurement should be correctly measured.



BPD is measured at the level of third ventricle and thalami.



Abdominal Circumference is measured at the level of gall bladder and stomach where rib is symmetrical and right and left portal vein are continuous with each other.



Only the ossified portion of the metaphysis and diaphysis excluding the cartilage is measured for FL .



Thigh circumference is measured at the middle of the thigh where bone profile is as round as possible and the boundary of the thigh profile is

REVIEW OF LITERATURE

(1)Irina Burd and associates (2009) ⁽¹⁾

Is Sonographic Assessment of Fetal Weight Influenced by Formula Selection? This is a prospective study of 81 cases. The aims of this study were to assess and compare the performance of different EFW formulas in predicting actual birth weight (BW) in an urban population. Fourteen published formulas, derived from populations comparable to ours, were used to recalculate EFWs from the same initial measurements. The accuracy of the EFWs obtained from the different formulas was compared by percentage error methods using bias and precision and Bland-Altman limits of agreement methods. Sensitivity and specificity for prediction of being small for gestational age (SGA) were calculated. Patients with an EFW determined within 7 days of delivery were considered eligible for the study.

Formula C of Hadlock [Hadlock C; $\log_{10} BW = 1.335 - 0.0034(\text{abdominal circumference [AC]}) (\text{femur length [FL]}) +$

$0.0316(\text{Biparietal diameter}) + 0.0457(\text{AC}) + 0.1623(\text{FL})$; had the best performance according to the bias and precision method. Bland-Altman limits of agreement confirmed these results.

Among the formulas, the sensitivity for detection of SGA ranged from 72% to 100%, and specificity was 41% to 88%. Hadlock C had the optimal sensitivity/specificity. Fourteen formulas showed considerable variation of bias and precision in our population as well as a wide range of sensitivities and specificities for SGA. The choice of the appropriate formula for EFW in a given population should be based on objective and explicit criteria. Consideration of bias and precision for the formula in the population being assessed is critical and may affect clinical care. Cases were identified on the basis of maternal criteria for preeclampsia (by blood pressure, proteinuria, and laboratory evaluation). Controls were prospectively enrolled from women undergoing delivery at term

Using Pub Med, all available (logarithmic and non logarithmic) formulas for sonographic fetal weight estimation were searched. From the pool of all available formulas, formulas were

selected for this study on the basis of population characteristics from which they were derived.

Of the eighty-one fetuses studied (41 cases and 40 controls), 28% were SGA, 67% were African American, 24% white, 8% Asian, and 1% reported as other. The median gestational age was 37.6 weeks (range, 27.1–40.8 weeks). The median birth weight was 2693 g (range, 595–4620 g). The mean difference between the EFW and BW ranged from 18 to 517 g when all of the formulas were evaluated. An "ideal" EFW measurement by Sonography should have a very low bias (no systematic confounders), a high level of precision (lowest random error), and consistency of the results across the weight ranges.

In conclusion, the study suggests that Hadlock C was the best performing formula in our population for accurately predicting BW and SGA,

(2) S.Yarkoni and associates (2009)⁽²⁾ : Intrapartum fetal weight estimation - a comparison of three formulae: This is a prospective study of 63 patients in labor. All patients delivered within 24 hours

of ultrasound examination. Aim of this study is to determine the relative accuracy of fetal weight estimation using the Biparietal diameter (BPD), the abdominal circumference (AC), and the femur length (FL) in three formulae (BPD/AC, FL/AC, and BPD/AC/FL). A good correlation was found between the estimated fetal weight and the actual birth weight, using the three formulae: BPD/AC ($r = 0.96$); FL/AC ($r = 0.95$); and BPD/AC/FL ($r = 0.96$). The FL/AC formula overestimated fetal weight (P less than 0.01), however, particularly in fetuses weighing more than 2000 g. The mean percentage error with the BPD/AC formula was 0.99 per cent, 3.82 per cent with the FL/AC, and 2.43 per cent with the BPD/AC/FL formula. This study showed that although all three formulae were comparable, the best estimation of the birth weight was obtained when either the BPD/AC or the BPD/AC/FL formulae were used. Additionally, the results demonstrate that reliable estimates of fetal weight can be made even at term or in laboring patients.

(3) S. Raman and associates (2008 online) ⁽³⁾

Clinical Versus Ultrasound Estimation of Fetal Weight: This is a prospective study with a sample size of 50 patients who had their fetal weight estimated by 3 clinicians of different seniority and compared to the ultrasound estimated fetal weights using 3 different formulas. All the patients delivered within 24 hours of their clinical and ultrasound estimates. The birth weight ranged from 1800 to 4500gms among the 3 different races (Malay, Chinese and Indians). The results showed that there was no significant difference in birth-weight estimation amongst the 3 clinicians as well as between the 3 ultrasound formulas used.

There was however significant difference between these 2 groups when compared with the actual birth-weight with clinical estimation being superior to ultrasound estimation in our population. This level of significance did not extend beyond 4,000 g fetal weight (actual) thus making both clinical and ultrasound estimation of fetal weight equally accurate after 4,000 g.

In clinical medicine there is a tendency to give more importance to an opinion expressed in a typewritten report

concerning a pathology or radiology investigation overriding the clinician's opinion which is often more accurate. Obstetricians are well aware of the fallibility of their clinical judgment when applying it to the outcome of trial of labor and assessment of fetal weight. Thus clinical opinion tends to be unjustifiably underrated.

However the importance of estimation of fetal weight is crucial when the baby is small with questionable viability or large enough to warrant Caesarean section because of the risk of severe morbidity from shoulder dystocia or uterine rupture if the patient has had a previous Caesarean or has a breech presentation.

Ultrasonography is often very useful and accurate in assessment of fetal weight at gestations below 30 weeks as it is more likely to be underestimated by the clinician when the fetus is premature and growth retarded. There is too much emphasis on fetal weight in case of cephalopelvic disproportion.

This has important implications for developing countries where there is a lack of technologically advanced ultrasound machines capable of doing sophisticated functions like fetal weight

estimations but has experienced clinicians who could perform this function equally well if not better.

(4). O.AYOOLA, E.O.ORJI AND ASSOCIATES (2008): ⁽⁴⁾

Accuracy of various ultrasonographic formulas in predicting fetal weight in Anigerian population: This is a prospective study involving 100 antenatal women. Objective of this study is to find out the ultrasonographic formula with the greatest accuracy in predicting birth weight and the influence of scan delivery interval, placentation and amniotic fluid index on the estimation of fetal weight. Abdominal Ultrasonography was performed in an ultrasound machine; with transducer frequency of 3.5 MHz. The parameters measured include Biparietal diameter, femur length, abdominal circumference, amniotic fluid index and placental location.

The age ranges of the women studied were from 22 to 45 years with a mean of 30.9 years. The range of actual birth weights in grams was from 2200 to 4600, mean of 3238 and standard deviation 452. The accuracy of weight prediction formula improved as the number of fetal parameters increases up to three. Several formulae

had been developed Shepard, Hadlock, Campbell, Nzeh among others.

Various formulae such as Shepherd, Hadlock 1 and 2, Nzeh 1 and 2 were compared. Statistical Analysis was done by Student's T Test. A new formula was derived using linear regression analysis: $\text{Log}_{10} (\text{estimated fetal weight}) = [2.8770.00343 (\text{BPD} \times \text{AC}) + 0.194 (\text{BPD} \times \text{FL}) - 1.941 \text{Log}_{10} \text{BPD} + 12.514 \text{log}_{10} \text{FL} + 0.0064 \text{BPD} + 0.34 \text{AC} - 2.571 \text{FL}]$

Patients scanned within the first 7 days to delivery constituted 71% of patients while those scanned between 8 and 14 days constituted 29% of patients. With a scan delivery interval of up to 7 days the first formula derived by Nzeh gave the least bias ($P < 0.001$, mean percentage error 11.35% and standard deviation error of 12.46%). While with a scan delivery interval of 8 to 14 days the second formula derived by Nzeh gave the least bias ($P < 0.05$ mean percentage error of 7.9%, standard deviation error of 11.5%.)

This is due to the fact that fetuses gain weight rapidly during the last trimester of pregnancy. This therefore may cause estimation

of fetal weights to be less accurate the longer the scan delivery interval.

The location of the placenta did not significantly influence the prediction of birth weight by any of the formula in the study however it was noted that the first formula by Nzeh gave the least bias with placenta lying both anterior and posterior.

The effect of the amniotic fluid index on prediction of birth weight could not be determined in this study as none of the patients was noted to have oligohydramnios ($AFI < 5\text{cm}$). Other information derived from the patients was age, gravidity, parity and medical history. All fetuses were scanned within two weeks prior to delivery.

In this study, there was under estimation of fetal weights with babies less than 2000 g while babies weighing greater than 4200 g had their weights overestimated. In comparing the formulae used in the estimation of fetal weight that have been studied, it was discovered that the use of multiple fetal parameters and in particular the combination of the Biparietal diameter, femur length and abdominal circumference gave the best result.

However, for the scan delivery intervals of up to 7 days, the second formula by Nzeh showed the highest degree of bias when compared to the other formula which had P values less than 0.0001. All the formulae over estimated actual birth weights regardless of scan delivery interval.

The conclusion from this study is that the formulae derived by Nzeh will be most useful in predicting birth weights. Different formulae have different degrees of accuracies in different environment. It should however be noted that scan delivery interval is one of the modifying factors in accurate prediction of fetal weights.

(5) Maria Regina Torloni, Nelson Sass and associates (2008): ⁽⁵⁾

Clinical formulas, mother's opinion and ultrasound in predicting

birth weight: This is a prospective study involving 100 full-term, cephalic, singleton pregnancies delivered within three days of fetal weight estimation at a tertiary public teaching hospital in São Paulo, Brazil. This study is aimed to evaluate the accuracy of clinical

formulas for fetal weight estimation compared to maternal and ultrasound estimates.

Upon admission, the mother's opinion about fetal weight was recorded. Symphyseal-fundal height and abdominal girth were measured and two formulas were used to calculate fetal weight. An ultrasound scan was then performed by a specialist to estimate fetal weight. The ultrasound fetal weight was calculated automatically by the equipment, using Hadlock's reference table, which used the Biparietal diameter, abdominal circumference and femur length. All participants delivered within the next three days following the FWE, and the infants were weighed using a digital balance, immediately after birth.

The four estimates were compared with the birth weight. Chi-squared analysis was used to determine whether the percentage of estimates within 10% of the actual birth weight was different between the clinical, maternal and ultrasound estimates of birth weight. A p-value < 0.05 was considered significant.

42% of the women were primi. 70% were Caucasian. 24% were obese (> 90 kg). Hypertensive disorders were present in 30 patients, 5 were diabetics and 15 had various other maternal complications (anemia, epilepsy, thyroid disease, cardiac disease, lupus or deep vein thrombosis). 63% were in spontaneous labor, while 37% were admitted for elective induction or cesarean section. The mean fundal height (\pm standard deviation, SD) was 35.7 ± 2.8 cm (range 28-43) and the mean maternal abdominal circumference was 102.6 ± 10.3 cm (range 83-130). There were 13 neonates that weighed over 4,000 g. No significant differences in the percentage of estimates within 10% among the four methods were detected using chi-squared analysis ($p > 0.05$).

The percentage of correct estimates by primi women did not differ significantly from that of parous women (57% versus 68%, $p = 0.38$). Fetal weight estimation using a measuring tape and two different clinical formulas was as accurate as maternal or USG estimates for predicting the infant's actual birth weight within 10%. Using Dare's formula and Johnson's formula, the residents involved

in the present study correctly predicted birth weight ($\pm 10\%$) in 57% and 61% of the cases, respectively.

Only Hadlock's formula was used for ultrasound FWE. The percent of ultrasound predictions within 10% of the actual birth weight obtained in the present study (65%) is within the reported range (23-78%)

The accuracy of maternal estimates $\pm 10\%$ in the present study (57%) did not differ from the values previously reported 53.5%. It had been expected that parous women would perform better than nulliparous with regard to predicting birth weight, but the difference between them was insignificant. Maternal characteristics such as age, education level, maternal weight and mean birth weight of children born previously did not affect the accuracy of maternal estimates.

The mother's body mass index (BMI) was calculated. This "late pregnancy" BMI was used in order to determine the effect of the current BMI on the FWE. The overall mean fetal weight estimated through Johnson's formula did not differ significantly from

the actual birth weight, the mean estimated fetal weight among obese women (admission BMI > 29.9) was significantly different from the mean actual birth weight ($p = 0.0002$).

The present study indicates that, among full-term singleton cephalic pregnancies, fetal weight estimation using a measuring tape and two different clinical formulas is just as accurate as maternal and ultrasound estimates for predicting the actual birth weight ($\pm 10\%$). These simple clinical methods for FWE are easy to perform and teach and may be useful, inexpensive and practical tools for predicting birth weight, especially for less experienced examiners.

(6)Hebbar Shripad and associates (2007) ⁽⁶⁾

Role of fetal thigh circumference in estimation of birth weight by ultrasound: It is a prospective study involving 110 pregnant women in whom fetal anomaly is ruled out. Clinical estimation of fetal weight was done by Johnson's and Insler's formula. Ultrasonic parameters - Biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), femur length (FL) and thigh circumference were measured using standard techniques. For

measuring Thigh circumference whole length of femur from greater trochanter to the distal metaphysis was imaged. Transducer was then rotated by 90 to obtain a cross sectional profile of the middle of the thigh at a position that the bone profile was as round as possible and the boundary of the thigh profile well defined. TC was determined with elliptical approximation three times and the average was taken as the final measurement.

Ultrasound estimation of fetal weight was done by Hadlock and Vintzileo formula. Fetal weights were estimated within a week prior to delivery. Within half an hour of delivery, neonates were weighed on a weighing scale. Birth weights obtained by various ultrasound and clinical formulas in different weight categories were statistically analyzed and compared with each other.

Of 110 women examined, 55% were primigravidas and 45% were multigravidas. Thirty-nine (36%) neonates weighed less than 2500g, 33 (30%), between 2501 and 3000g, 30 (27%) between 3001 and 3500g, and 8 (7%) weighed more than 3500g. Mean birth weight was 2822gms. Mean Predicted weight by Johnson was 3227, Insler was 3194, Hadlock 301gms. and Vintzileo was 2711gms. Actual

birth weight was compared against predicted birth weight in different weight categories.

Up to 3500g, Vintzileos proved better than all methods and this difference was statistically significant ($p < 0.05$). However in weight group > 3500 g, Vintzileos was comparable to Insler, Johnson and Hadlock. Mean of difference from actual birth weight in different weight categories showed that Vintzileos model was closest to the actual birth weight in all weight groups. It was 141gms for Vintzileo, 263gms for Hadlock, 414gms for Johnson and 377gms for Insler's formula.

Vintzileos model was superior to all other models in its ability to predict the estimated birth weight within 10% actual birth weight. It was 95% in < 2500 gms category, 73% for 2500-3000gms, 96% for 3000-3500gms and 88% for < 3500 gms category.

Statistical analysis was done using Chi-Square test in evaluating two methods to predict birth weight in different weight groups and p value calculated. Vintzileo method was better than Insler, Johnson and Hadlock formula with a p value < 0.05 in all

weight categories except in above 3500gms category. In this Vintzileo was comparable to other formula with $p \text{ value} > 0.05$.

Clinical methods are subjected to significant margin of error and are not useful in malpresentations, maternal obesity, multifetal pregnancy, polyhydramnios and oligoamnios. Ultrasound using parameters such as BPD, AC and FL is better when compared with clinical methods and is more reproducible.

Conclusion - Incorporating thigh measurements prove most useful in predicting fetal weight when growth abnormalities are present. Estimated fetal birth weight using TC correlated well with actual birth weight in all birth weight categories and was superior to clinical and birth weight formulas using BPD, HC, AC and FL measurements.

Thigh circumference measurement was simple and there was better accuracy when it was combined along with BPD, HC, AC and FL measurements.

(7) Atalie Colman and associates (2006) ⁽⁷⁾

Reliability of ultrasound estimation of fetal weights in term singleton pregnancies: This is a retrospective study in which 1177 infants were studied. Data were collected retrospectively for pregnant women with singleton pregnancy more than 37 weeks gestation that had undergone ultrasound estimation of fetal weight within seven days of delivery. Ultrasound fetal weight estimations, calculated using a locally modified Woo formula, were compared with the infant's actual birth weight. Ultrasound parameters taken were BPD, AC and FL. Statistical analyses were performed using the Student's t-test and linear regression analysis. Chi-squared tests with $p < 0.05$ was considered significant.

The mean actual birth weight within the study cohort was 3325 g (range 1620–5580 g). 98 infants (8%) weighed less than 2500 g, and 170 (14%) weighed more than 4000 g.

The ultrasonic estimation of fetal weight significantly correlated with actual birth weight for all infants ($R = 0.879$, $p < 0.001$). 75% of all fetal weight estimations were within 10% of actual birth weight. In one out of four women, the error was $> 10\%$.

The difference was $>20\%$ in 3% of the weight estimations. The mean absolute error of fetal weight estimations was $7.0\pm 5.7\%$ ($n=1177$). This did not differ significantly between infants of different birth weights (<2500 g, $7.3\pm 6.4\%$, $n=98$; $2500\text{--}3999$ g, $6.9\pm 5.6\%$, $n=909$; ≥ 4000 g, $7.3\pm 5.8\%$, $n=170$) nor between diabetic and non-diabetic pregnancies (diabetic $8.3\pm 6.5\%$, $n=48$; non-diabetic $6.9\pm 5.6\%$, $n=1129$).

Although the absolute percent errors for fetal weight estimation were similar in each of the birth weight categories, the direction of the error (i.e. underestimation vs overestimation) differed. Ultrasonic estimation of fetal weight tended to overestimate the weight of small infants with mean signed error of $+3.5\%\pm 9.1\%$, and underestimate the weight of large infants with mean signed error of $-3.3\pm 8.7\%$, $n=170$).

48 (4.1%) women in the study cohort had diabetes in pregnancy. The birth weight of the infants born to these women was significantly higher (3603 ± 629 g) than in non-diabetic women (3314 ± 604 g, $n=1129$) ($p=0.001$). Their weights were underestimated with mean signed error = $-5.1\pm 9.2\%$. This

underestimation was attributed to the greater liver size and the increased subcutaneous fat that commonly occurs in fetuses of women with diabetes not being reflected in the formulae used in ultrasound fetal weight estimation.

Amongst the non-diabetics ultrasound detected only three out of every five infants weighing more than 4000g and only half of the infants weighing more than 4500g. Our findings thus confirm that ultrasound does not reliably detect macrosomia, at least in non-diabetic mothers. Until more reliable methods are developed to determine fetal macrosomia, the use of ultrasound to assess fetal weight in singleton term pregnancies must be interpreted with caution.

Ultrasound were performed <7 days prior to delivery. Although fetal weight estimations made 4–6 days before delivery tended to slightly underestimate birth weight in our study, the error was small ($-1.3 \pm 8.9\%$) than done within 3 days.

(8)George Naomi and associates (2005) ⁽⁸⁾

Clinical and sonographic estimation of fetal weight performed during labor by residents: This is a prospective study of 192 patients. This study was undertaken to assess the accuracy of both clinical and sonographic estimations of the fetal weight (EFW) performed during the active phase of labor by residents. The study protocol consisted of achieving clinical, followed by sonographic EFW by the admitting resident during the active phase of labor.

Patients who had an EFW (clinical or sonographic) within the last 2 weeks were excluded from the study. In addition, the effect of the following variables on the accuracy of the EFW were examined: maternal age, maternal weight and body mass index, parity, the Bishop score before obtaining the EFW, gestational age, birth weight, and the postgraduate year of the examiner.

The Pearson correlation, χ^2 test, and Student t test were the statistical analyses used. Sensitivity, specificity, and positive and negative predictive values for clinical and sonographic EFW for detecting macrosomia (birth weight ≥ 4000 g) was also calculated.

The coefficient of correlation between the clinical and sonographic EFW and the actual birth weight was 0.59 ($P < .0001$) and 0.65 ($P < .0001$), respectively. Clinical EFW was correct (within $\pm 10\%$) in 72% of the cases and the sonographic EFW was correct (within $\pm 10\%$) in 74% of the cases. However, the sensitivity of predicting birth weight of 4 kg or more was only 50% for both clinical and sonographic EFW, with 95% and 97% specificity, respectively.

None of the clinical variables that were tested were significantly associated with the accuracy of the EFW. Both clinical and sonographic EFW performed during the active phase of labor by residents correlate with the actual birth weight but have poor sensitivity in detecting macrosomic fetuses. Sonographic EFWs offer no advantage over clinical EFWs.

(9) Bhandary Amrita and associates (August 2004) ⁽⁹⁾

Comparative study of various methods of fetal estimation in

term pregnancy: This is a prospective study involving 200 pregnant women near term. Aim of this study is to comparative evaluation of fetal weight using Johnson's formula, Dawn's formula, Abdominal

girth X Symphyseal fundal weight, Ultrasound formula of Hadlock.

The fetal weight estimation was done within 7 days of delivery. The results were correlated with the actual neonatal weight.

The fetal weight were categorized into <2500gms, 2500-3000gms., 3000-3500gms and >3500gms. Comparative analysis of the results with various weight categories was done. Among the case studied, 45% were primi and 55% were multi. 75% delivered vaginally and 25% delivered by caesarian section. 7% of the babies weighed <2500gms, 22.5% weighed between 2500-3000gms, 10.5% weighed between 3000-3500gms and 2.5% weighed >3500gms. Average error of weight in grams was calculated for various weight groups. It was 224 for Insler, 464 for Dawn, 292 for Johnson and 299 for Hadlock. It was least for Insler's formula followed by Hadlock formula. In the above 3500gms category all formulas underestimated the fetal weight. In other categories Dawn and Insler underestimated the actual weight while Hadlock and Johnson overestimated the fetal weight.

Least error among clinical method was with Insler's formula and Maximum error was with Dawn's formula. 85% of the calculated weights were within 15% of the actual birth weight in both Insler's method and Hadlock's method. Standard deviation of prediction error was 258 with Hadlock, 272 with Insler, 309 with Johnson and 441 with Dawn' formula. The prediction error was least with Hadlock. Among the clinical formula Abdominal girth X Symphysiofundal height predicts the birth weight more accurately than other method. This can be very useful in a Developing country like India.

(10) M.W.Pang and associates (2004) (¹⁰)

Validation studies for USG fetal weight estimation models for Hongkong Chinese singleton pregnancies: Most of the fetal weight estimation models have been derived from data of western populations. Ethnicity and secular changes alter the birth weight. Fetal weight estimation models of other ethnic community when applied to our locality should be validated for their clinical applicability. Otherwise it would result in systemic erroneous

applications. Fetal weight estimation was done based on Hadlock Formula - 1, 2, 3, &4, Campbell, Sheppard, Woo 1 &2. Warsof. Correlation coefficient was found for each formula against actual weight. Interclass correlation coefficient estimated. Hadlock had least systemic bias.

(11)Baum Jonathan, D.Gussman Debra and associates (2002) ⁽¹¹⁾

Clinical and patient estimation of fetal weight vs. ultrasound estimation: This is a nonblinded prospective study with a sample size of 200 antenatal women at 37 to 42 weeks gestation. Fetal distress and fetal anomalies were excluded from the study. Junior and senior obstetric residents' first estimated fetal weight clinically and sonographically, in alternating order and patients then made an estimate. Sonographic measurements were obtained for Biparietal diameter, abdominal circumference, and femoral length.

The mean age of the study group was 29 and the mean parity was 0.7. The mean estimated gestational age was 39.3 weeks, and means actual birth weight, 3407 g. Both clinical and sonographic estimates of fetal weight at term were more accurate than patient

estimates, but there were no significant differences in the proportions of estimates within 10% of actual birth weight. Nearly two thirds of clinical estimates (64%) and 62.5% of sonographic estimates met this criterion.

Senior residents were more accurate in both their clinical and sonographic estimates than were their junior counterparts (75% vs. 59% for clinical estimates; 73% vs. 58% for sonographic estimates). Fetal weight estimates did not differ significantly between nulliparous and multiparous women. Sonography is widely accepted as the most accurate means of estimating fetal weight during pregnancy and in labor. Few studies have directly compared it with clinical methods.

The authors conclude that Sonography offers no advantage over clinical estimates of fetal weight at term. Patient estimates should be viewed as equally valid in light of the need for realistic, achievable standards at community hospitals as well as academic medical centers.

(12) Mehdizadeh A and associates (2000) ⁽¹²⁾

Comparison of clinical versus ultrasound estimation of fetal

weight: This is a prospective study involving 200 Iranian pregnant women. Aim is to compare the accuracy of fetal weight estimation using clinical and ultrasound methods with actual birth weight. The results showed that there was statistically significant difference between clinical estimate of fetal weight and actual birth weight, as well as between ultrasound estimation and actual birth weight. The mean error of clinical estimation was 101 g, or 32 g/kg, for a 3.2% error. The error of ultrasound in the same population was 141 g, or 45 g/kg, for a 4.5% error.

Analysis of these data revealed statistically significant difference between the mean error of clinical estimation and ultrasound estimation of fetal weight. Our study indicates that the mean clinical estimate of fetal weight is equal to ultrasound for the estimation of fetal weight in our population. This has important implications for developing countries where there is a lack of

technologically advanced ultrasound machines capable of performing sophisticated functions like fetal weight estimation.

(13) Ren-Ling-A and associates (1997)¹³

Prediction of Fetal weight by fetal arm circumference by three dimensional Ultrasonography: This is a prospective study on 105 pregnant women without fetal structural anomaly or aneuploidy. Both the traditional two-dimensional ultrasonographic parameters and three-dimensional Ultrasonography for fetal upper arm volume were measured within 48 hours of delivery. The upper arm volume correlated well with birth weight ($r = 0.92$, $n = 105$, $p < 0.0001$). With use of linear and polynomial regression, we obtained a best-fit new formula - Birth weight = $1088.60 + 36.024 \sqrt{\text{Upper-arm volume}}$. The accuracy of this new formula is compared with that of two Chinese equations predicting fetal weight reported before and other formulas commonly used in the world as well.

This study has validated the application of upper-arm volume by three-dimensional Ultrasonography in estimating fetal weight. Further larger series are needed to confirm our findings.

(14). R.Favre and A.M.Bader (1995)

Prospective study on fetal weight estimation using limb circumference obtained by three dimensional ultrasound: This is prospective study involving 213 patients with term gestation in whom fetal anomalies were ruled out. Ultrasound examination was done and the parameters measured were Biparietal diameter, Head Circumference, Abdominal Circumference, Abdominal diameter, Femur length, mid thigh circumference, arm circumference. Three dimensional ultrasound was done for limb measurements that were reproducible formed the basis of the study.

The whole population was divided into 3 groups- less than 10th percentile, more than 90th percentile and between 10 -90th percentiles. Two models were needed for accurate measurement of birth weight. One is for the small fetuses and the other is for the rest of the group. The accurate results were obtained for macrosomic fetuses with standard deviation of 8.8%.A formula was derived from a retrospective study using forward stepwise multiple regression analysis.

Of the 219 cases studied, average age of the patients was 28, Mean parity was 2; Average gestational age was 38 weeks. Average birth weight was 2904gms. And the mean time between weight estimation and delivery was 2.09 days. The new formula was tested and validated in all groups and compared with standard formula of Hadlock and Vintzileo. The accuracy of the formula depends on multiple regression coefficient, mean percent error and standard deviation. 16.5 % (n=38) were in <2500gms category. Standard deviation for the target formula was 13.5 and 33.5 for the global formula. In >3500gms category, there were 25 cases (11%), standard deviation for the target and global formula was 8.8 and 10.4. In the appropriate weight group (n is 150 – 70%) S.D was 9.4 and 10.4 respectively. The standard deviation is a useful measure of true variance or positive predictive error.

Vintzileo had less random error but underestimated the fetal weight. It was accurate in lesser weight categories. The newly derived formula incorporates fetal arm circumference and is more accurate particularly in the above 3500 gms group with S.D. of 8.8.

The accuracy of the new formula compared well with Vintzileos and Hadlock formula.

MATERIALS AND METHODS

This is a prospective study of 100 antenatal women who presented to labor ward, Department of Obstetrics and Gynecology Government Rajaji Hospital, Madurai in a time period between May 2010 to November 2010 for delivery. Ethical Committee clearance was obtained from the institution to undergo this study. After getting the consent all women were examined at term. General examination including height, weight, cardiovascular and respiratory system was done. Per abdominal examination followed by pelvic examination was done.

Patients included for the study:

- Full term singleton pregnancy.
- Delivery occurring within seven days of fetal weight estimation.

Patients excluded from the study

- Multiple pregnancy
- Preterm Labor.

- Maternal complications like PIH, Diabetes, Polyhydramnios, and Oligohydramnios etc.
- Fetal congenital anomalies, severely growth restricted Fetuses etc.

Parameters considered for fetal weight estimation were

For clinical methods

1. Symphysiofundal height in cms.
2. Abdominal girth at the level of umbilicus in cms.

For Ultrasound methods

1. Biparietal diameter in cms.
2. Abdominal Circumference in cms.
3. Femur length in cms.
4. Mid Thigh Circumference in cms.

Clinical methods of Fetal Weight estimation was done by using Johnson's and Insler's formula. Fetal weight estimation by Ultrasound was calculated by Hadlock and Vintzileo's formulas.

Fetal weight estimated by Hadlock formula was directly taken from the Ultrasound machine. Birth weight estimation by Vintzileo formula was calculated using the formula discussed before.

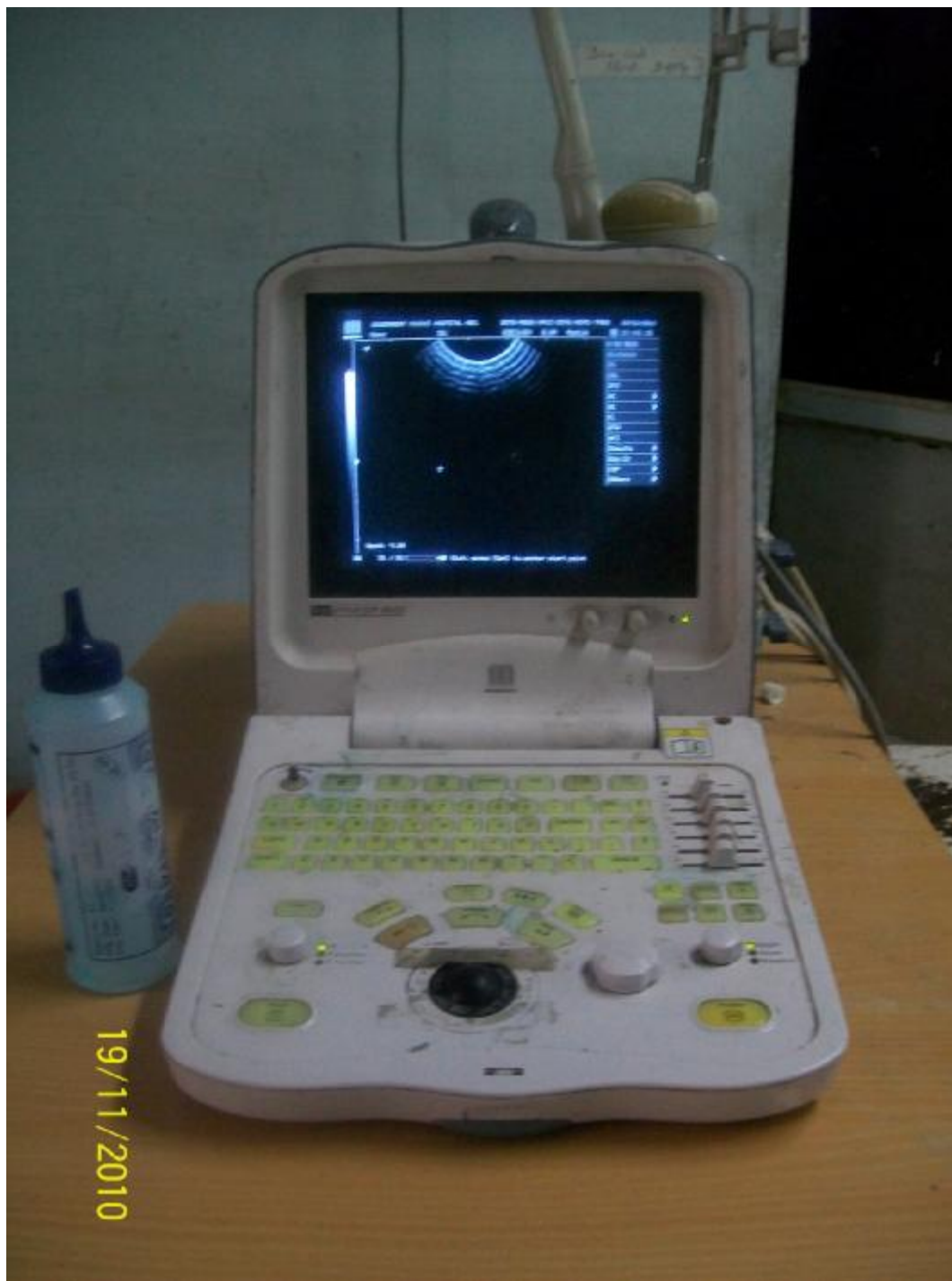
Ultrasound examination was done using a linear array real time ultrasound machine Mindray Digiprince DP-6600 equipped with a 3.5 MHz transducer available in the Obstetric and Gynecology Department. The actual fetal weight was measured using a weighing scale within one hour of delivery. If the delivery did not occur within seven days then the fetal weight was repeated again.

The estimated fetal weight obtained by two clinical methods and two ultrasound methods were compared with actual neonatal weight.

The information collected regarding all cases were recorded in a Master Chart. Data analysis was done with a help of a computer using Epidemiological Information Package. Using this software standard deviation X^2 and 'p' values were calculated. A 'p' value less than .05 is taken to denote significant relationship.



Actual neonatal weight in grams is taken within 1 hour of delivery in a weighing scale.



Mindray Digiprince DP-6600 ultrasound equipment available in the Obstetric and Gynecology Department with a convex 3.5 MHz transducer

RESULTS

A. PROFILE OF CASES STUDIED

Table 1: Age Distribution

Age group	No of cases	Percentage
Less than 20	14	14%
21 to 25	60	60%
26 to 30	24	24%
More than 30	2	2%

Total number of cases studied was 100. Of them,

- 60 % of the patients were in the age group of 20 to 25 years.
- Average age of the patient studied was 24 years.
- Age of the patient has no correlation with the fetal weight predicted by either means – Clinical or Ultrasound methods.

Age Group in years

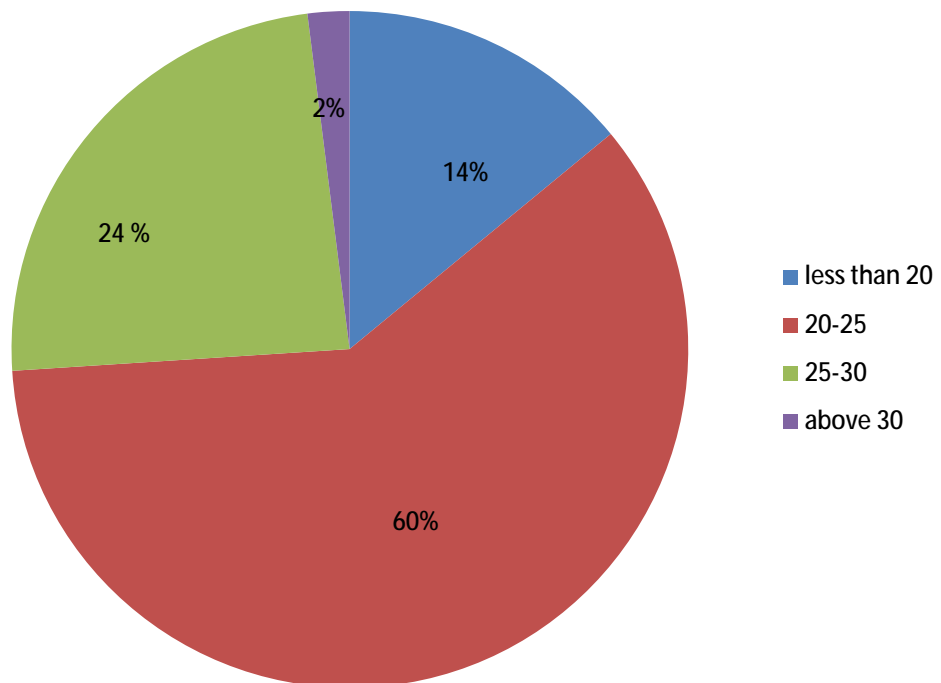
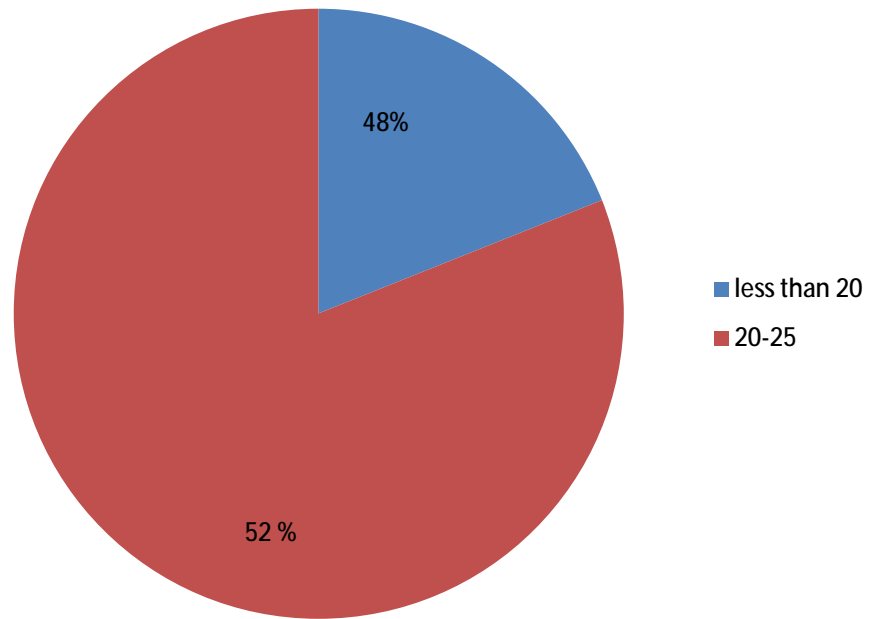


Table 2: Parity

Parity	No of cases	Percentage
Primi	48	48%
Multi	52	52%
Total	100	100%

- 52% of the patients were multi gravida
- 48% of the patients were primi gravida.
- Parity of the patients does not alter the predicted fetal weight by either clinical methods or by Ultrasound methods.

PARITY



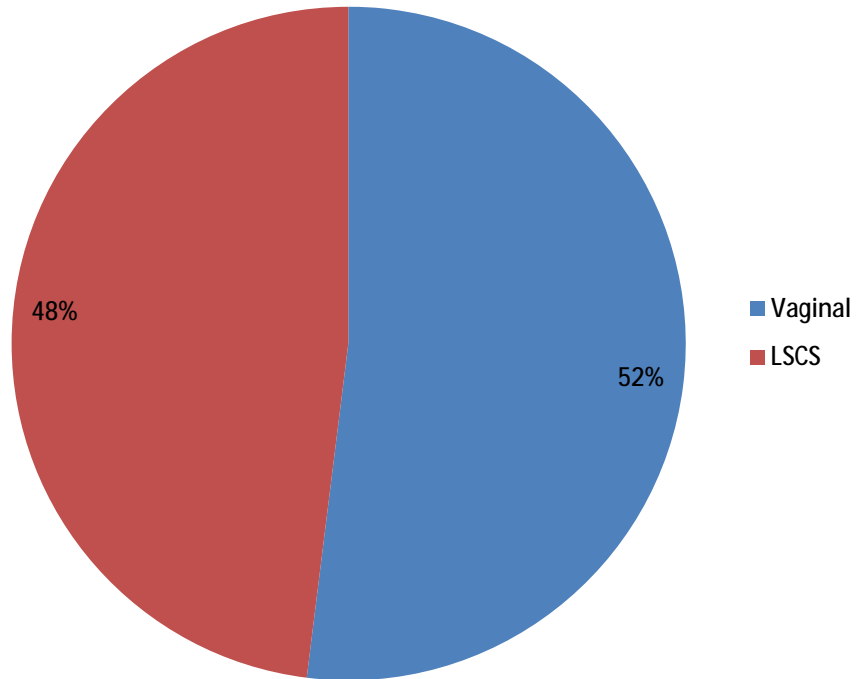
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Table 3: Mode of Delivery

Mode of delivery	No. of cases	Percentage
Vaginal	58	58%
LSCS	42	42%
Total	100	100%

- 58% of the patients delivered vaginally.
- 42% of the patients delivered by caesarian section. Of these 26% were post caesarian pregnancies.
- Being a tertiary referral centre and increase in number of post caesarian pregnancies there is a high incidence of caesarian deliveries.

Mode of delivery



B. Comparison Of The Formulas In Different Weight Groups And Its Significance

Table: 1

Comparative Analysis Of Birth Weights In Different Groups

Methods	Less than 2500gms	2501 to 3000gms	3001 to 3500gms	More than 3500gms	Overall Weight
No of cases	N=9(9%)	N=51(51%)	N=32(32%)	N=8(8%)	N=100
Actual Birth Weight(mean)	2456	2855	3235	3625	3042
Johnson	2721	3027	2964	3157	2945
Insler	2700	2989	3022	3129	2906
Hadlock	2585	2751	3116	3235	2897
Vintzileos	2625	2906	3300	3550	3162

Estimated fetal weight was calculated for all the cases using 4 different formulas. This was compared with the actual Birth Weight of the neonate measured within one hour of delivery.

Actual Birth weight of the neonate is categorized into 4 groups –

- Less than 2500gram,
- 2501 to 3000grams,

- 3001 to 3500 grams and
- More than 4000grams.

The MEAN of the estimated birth weight using different formula in different weight categories were taken for comparative analysis. Percentage of neonates in each weight categories were,

- less than 2500 grams – 9% (n=9)
- 2501 to 3000grams – 51% (n=51) forming the major group
- 3001 to 3500 grams - 32% (n=32)
- more than 3501gms – 8% (n=8)

Overall mean birth weight was 3042 grams.

Standard deviation for Johnson's formula was 232, Insler's formula was 253, Hadlock was 198 and that for Vintzileo was 61.2

Vintzileo's method proved better than all methods in different weight groups. Particularly in the weight group of more than 3500 grams, Vintzileo was very accurate. This result varies from previous study that shows Vintzileo is less accurate in above 3500grams group. In less than 2500gms category Vintzileo was comparable to Hadlock formula.

Comparison Of Different Formula In Different Weight Categories

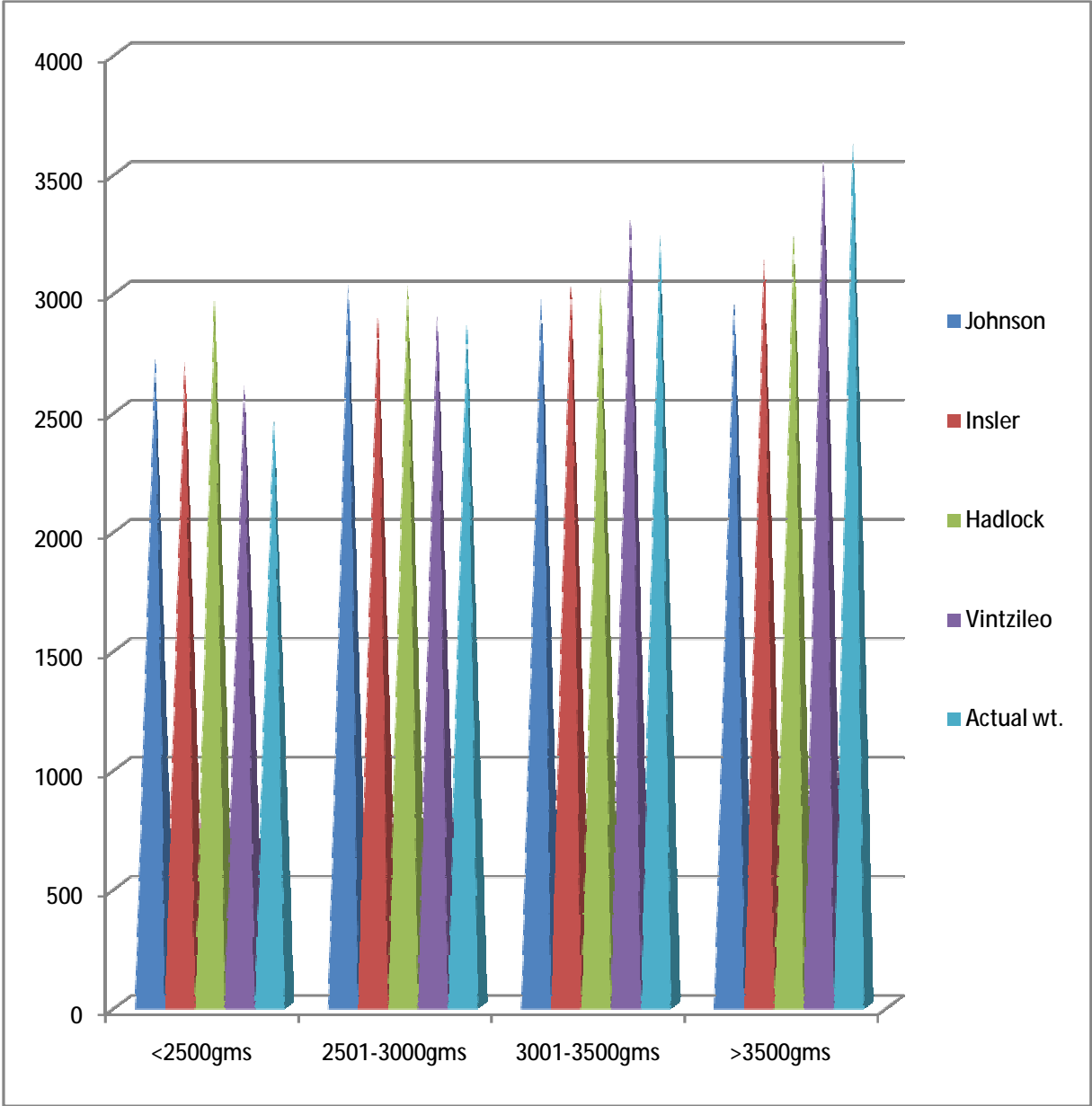


Table 2:

Mean Of Difference From Actual Birth Weight In

Different Weight Categories

Methods	Less than 2500gms N=9	2501to 3000gms N=51	3001 to 3500gms N=32	More than 3500gms N=8
Johnson	265	172	271	468
Insler	244	134	213	496
Hadlock	129	104	219	390
Vintzileos	179	51	65	75

Mean of difference of predicted weight against actual birth weight in all weight categories shows clearly showed Vintzileo has least difference from the actual weight. In the Birth weight group of

less than 2500gms it is comparable to Hadlock formula. Among the clinical methods Insler's method using abdominal circumference shows less difference than Johnson's formula.

- Vintzileo predicts the birth weight within 2 % in all the categories except in <2500gms which was 8%.
- Hadlock predicts the birth weight in <2500gms within 6-7%.
- All the formulas predicted the birth weight in 2500 – 3000gms category (n=52) that forms a major of the sample size within 8%.

Difference of weight in grams from actual birth weight in

Different weight categories

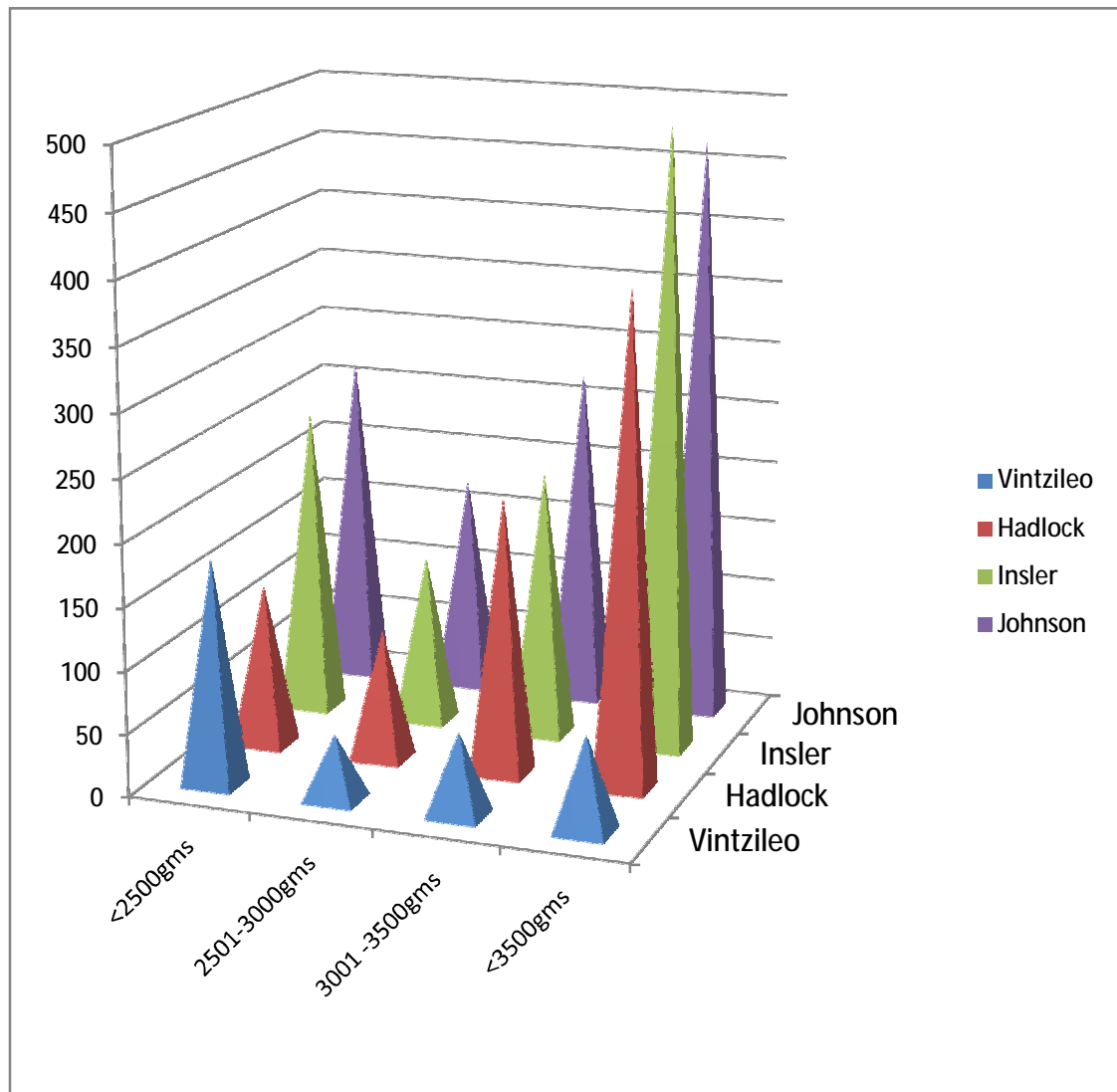


Table: 3

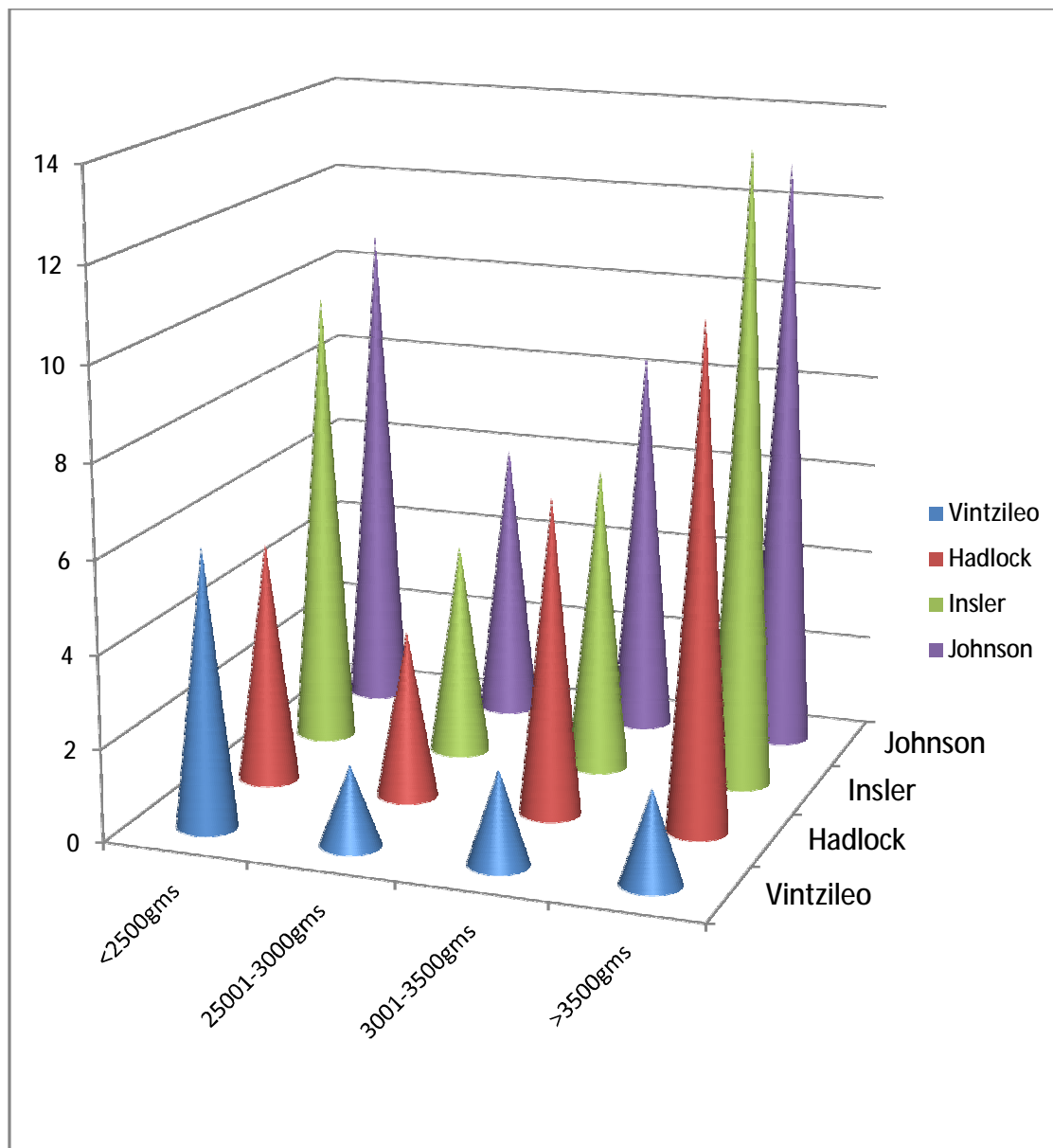
**Percentage Of Error Of Different Formulas In
Different Weight Categories**

Method	Less than 2500gms	2501 – 3000gms	3001 – 3500gms	More than 3500gms
Johnson	10.79%	6.02%	8.38%	12.9%
Insler	9.93%	4.69%	6.58%	13.68%
Hadlock	5.25%	3.64%	6.76%	10.76%
Vintzileo	6.73%	1.79%	2.01%	2.07%

Percentage of error is calculated as difference in calculated weight divided by actual weight multiplied by 100. Here again Vintzileo is accurate in all categories particularly in the 2501 to 3000grams category. Majority of the study group i.e.: 51% of the patients belong to this category where Vintzileo formula is the most accurate one.

Among the clinical methods Insler method is more accurate than Johnson.

Percentage Of Error Of Different Formulas In Different Weight Categories



Chi Square Analysis And P Value Of Different Formulas In Different Weight Categories

Birth Weight Up to 2500gms

Table: 4(a)

Method	Chi square	P Value	Inference
Actual weight Vs Johnson	49.54	<0.05 (0.001)	P value is significant
Actual weight Vs Insler	57.43	<0.05 (0.001)	P value is significant
Actual weight Vs Hadlock	77.9	<0.05 (0.001)	P value is significant
Actual weight Vs Vintzileo	87.30	<0.05 (0.001)	P value is significant

Table: 4(b)

Method	Chi square	P Value	Inference
Vintzileos Vs Johnson	22.5	<0.05 (0.001)	Vintzileos is better than Johnson
Vintzileos Vs Insler	16.09	<0.05 (0.001)	Vintzileos is better than Insler
Vintzileos Vs Hadlock	54.51	<0.05 (0.001)	Vintzileo is better than Hadlock

Birth Weight of 2501 – 3000 Gms

Table: 5(a)

Method	Chi square	P Value	Inference
Actual weight Vs Johnson	10.36	<0.05 (0.0013)	P value is significant
Actual weight Vs Insler	9.289	<0.05 (0.0121)	P value is significant
Actual weight Vs Hadlock	7.788	<0.05 (0.03)	P value is significant
Actual weight Vs Vintzileo	5.11	<0.05 (0.002)	P value is significant

Table 5: (b)

Method	Chi square	P Value	Inference
Vintzileos Vs Johnson	5.038	<0.05 (0.024)	Vintzileos is better than Johnson
Vintzileos Vs Insler	4.32	<0.05 (0.013)	Vintzileos is better than Insler
Vintzileos Vs Hadlock	8.26	<0.05 (0.004)	Vintzileo is better than Hadlock

Birth Weight of 3001 – 3500 Gms

Table: 6(a)

Method	Chi square	P Value	Inference
Actual weight Vs Johnson	22.702	<0.05 (0.0001)	P value is significant
Actual weight Vs Insler	14.024	<0.05 (0.0002)	P value is significant
Actual weight Vs Hadlock	14.82	<0.05 (0.0001)	P value is significant
Actual weight Vs Vintzileo	13.06	<0.05 (0.0003)	P value is significant

Table: 6(b)

Method	Chi square	P Value	Inference
Vintzileos Vs Johnson	34.21	<0.05 (0.0001)	Vintzileos is better than Johnson
Vintzileos Vs Insler	23.419	<0.05 (0.0001)	Vintzileos is better than Insler
Vintzileos Vs Hadlock	24.441	<0.05 (0.0001)	Vintzileo is better than Hadlock

Birth Weight above 3500gms

Table: 7 (a)

Method	Chi square	P Value	Inference
Actual weight Vs Johnson	34.57	<0.05 (0.0001)	P value is significant
Actual weight Vs Insler	51.96	<0.05 (0.0001)	P value is significant
Actual weight Vs Hadlock	45.25	<0.05 (0.0001)	P value is significant
Actual weight Vs Vintzileo	2.33	<0.05 (0.002)	P value is very significant

Table: 7 (b)

Method	Chi square	P Value	Inference
Vintzileos Vs Johnson	19.42	<0.05 (0.0001)	Vintzileos is better than Johnson
Vintzileos Vs Insler	33.11	<0.05 (0.0001)	Vintzileos is better than Insler
Vintzileos Vs Hadlock	27.72	<0.05 (0.0001)	Vintzileo is better than Hadlock

Tables 4, 5, 6 and 7 – Shows the results of Chi square test and P values of different formula in predicting birth weight in different weight categories.

All the formulas were compared against the actual birth weight and also against the Vintzileo formula. In all the categories of birth weight it is clearly understood that Vintzileo method incorporating thigh circumference provides a better model in predicting birth weight by ultrasound.

In birth weight of above 3500gms categories, the p value is extremely significant in the order of less than 0.0001. Showing Vintzileo is more accurate than other formula. In the less than 2500gms category Vintzileo is comparable with Hadlock. P value is significant (0.001). In other categories also Vintzileo proved better than other formula.

Among the clinical methods Insler's formula incorporating Abdominal girth and Symphysiofundal height predicts birth weight better than Johnson's formula with p value of 0.002.

DISCUSSION

This is a prospective study involving 100 antenatal women attending the labor ward. Fetal weight estimation was done by clinical and Ultrasound formulas. A newer parameter namely fetal mid thigh circumference was taken to predict birth weight using Vintzileo formula. All the four values were compared with the actual neonatal weight.

1. Maternal Age:

In our study of 100 cases 60% (n=60) of the cases belonged to the age group of 20-25 years. George Naomi ⁸ (2004) on comparing the clinical and USG estimation of fetal weight had concluded that age of the patient has no correlation to the prediction of birth weight.

2. Parity

In our study 48% (n=48) were primi gravida and 52% were multigravida. Prediction of birth weight does not rely on the parity of the patient. The percentage of correct estimates by nulliparous women did not differ significantly from that of parous women (57%

Vs 68%, $p = 0.38$). This result was shown by Maria Torloni (2008)⁵.

Baum Jonathan (2002)¹¹ also has shown similar results.

3. Mode of Delivery:

In our study, 58% of the cases delivered vaginally and 42% underwent caesarian delivery. Being a tertiary referral centre, 26% of the patients were post caesarian pregnancies who went for repeat caesarian section.

4. Estimation of birth weights:

In our study the predicted fetal weight was calculated by clinical and Ultrasound methods within two days of delivery for more accurate results. Ayoola (2008)⁴ has concluded in his study that fetal weight estimated before 7 days has % of error (7.9) than when taken after 8 days with % of error (11.35). Atalie (2006)⁷ in his study has stated that fetal weight predicted before 4 days reduces the error by 1.3%.

5.Fetal weight Categories:

The actual neonatal weight was calculated within 1 hour of delivery in a weighing scale and was categorized in groups. *Majority of the neonates (51%) were between 2500 – 3000gms. Extreme weight categories were 9% in <2500gms and 8% >3500gms. 32% of neonates were in 3001 – 3500group.*

Neonates weighing <2500grams was 9% in our study whereas it was 8% in Ataliecolman (2006)⁷, 18% in Favre (1994)¹⁴ and 36% in Hebbar (2007)⁶. Neonates weighing more than 3500gms were 8% in our study, 2.5% in Bhandary, 7%in Hebbar, 14% in Atalie Colman and 13% in Torloni.

6.Average Birth Weight in grams :

<i>In Our study – 3042</i>	Raman(2008) ³ – 3150
Irina(2009) ¹ - 2693	Ayoola (2008) ⁴ -3238
Hebbar(2007) ⁶ - 2822	Atalie(2006) ⁷ - 3325
Favre(2904) ¹⁴ - 2904	Baum(2002) ¹¹ - 3407

6. Mean difference of weight from actual weight in grams:

	Vintzileo	Hadlock	Insler	Johnson	Dawn
<i>Our study</i>	92.5	210	272	294	--
Hebbar	141	263	377	414	--
Bhandary	--	299	224	292	464

Our study shows that Vintzileo method has least difference from the actual weight in all the weight categories. Among the Clinical methods Insler is more accurate than Johnson. The mean difference of weight was less by Ultrasound methods when compared to clinical methods. Hebbar (2007)⁶ in his study has shown that Vintzileo has least difference than other formulas. Bhandary (2004)⁹ has shown that Insler has less difference than Johnson and Dawn's formula. Irina (2009)¹ in his study has shown a difference range of 18 – 517gms. The

7.Ability to predict the weight and percentage error:

In our study, Vintzileo had the least % of error of 1-2% in all the weight groups except in <2500 group where it is 6.7% and is comparable to Hadlock (5.25%). In >3500 grams category Hadlock and both clinical methods had similar % error of 10 -13%. In the 2501 – 3000grams category that formed the majority Vintzileo was accurate and other formulas were similar. Atalie Colman (2006)⁷ in his study has given a mean error of 7.3% in <2500 gms group and 6.9% <3500grams group.

Many studies have shown varying results for prediction of birth weight within 10%. Naomi (2005)⁸ in his study has shown it to be 72% for clinical and 74% for USG methods. Mehdizadeh (2002)¹² in his study has shown it to be 64% for clinical and 62% for USG methods. Bhandary (2004)⁹ has shown in his study that ability to predict within 10% for Insler formula was 85%.

8.No of Ultrasound parameters for fetal weight prediction:

In our study fetal thigh circumference has been measured and incorporated in Vintzileo formula. AC, BPD and FL are other USG

parameters taken. Yarkoni (2009)² has shown in his study that fetal weight estimation is more accurate whenever more than 3 parameters are taken, of which abdominal circumference is important. Ayoola (2008)⁴ in his study has also come with similar result.

9. Standard deviation for various formulas in different groups:

In our study the standard deviation for prediction of macrosomic fetus was 6% for Vintzileo. In <2500 grams group the standard deviation for Hadlock was 24, Vintzileo was 29. Standard deviation for prediction of macrosomic fetuses by Favre (1994)¹⁴ has shown to be 8%.

10. Chi square tests and P values:

Both the clinical formulas and USG formulas were compared with the actual neonatal weight. Vintzileo formula was compared with other formula in different weight categories. Chi square test and p values were calculated.

In our study, Vintzileo method proved to be better than Hadlock, Insler and Johnson formula with a significant p value of

0.001. In the fetal weight group of >3500grams Vintzileo has extremely significant p value of 0.0001. In the <2500grams category Vintzileo was comparable to Hadlock (p value was 0.001). The overall prediction for all weight categories is accurate in Vintzileo method than other formula.

Hebbar Shripad (2007) have concluded that Vintzileo formula using fetal thigh circumference predicts the fetal weight more accurately (p value of 0.001) He had concluded that Vintzileo is better in all weight categories except in >3500gms. His sample had 36% of cases in <2500gms category (only 9% in our study), 7% of the cases in >3500gms group (9% in our study). This difference in sample size is the cause for this variation in the values.

Favre (1995)¹⁴ in his studies have shown that incorporation of fetal thigh circumference adds to the accuracy of predicting birth weights where growth abnormalities are present. The standard deviation given by his study for macrosomic fetuses was 8.8% whereas in our study it is 6%. Vintzileo formula has less random error.

M.W.Pang (2004)¹⁰ has shown that Hadlock has less systemic bias. Irina (2009)¹ in his study has shown that specificity and sensitivity was optimum for Hadlock.(72 – 100 % sensitivity , 41 – 88% specificity). Raman (2008)³ has in his study concluded that USG correlation of fetal weight is superior to clinical methods but the level of significance did not extend beyond 4000grams.

In our study, Vintzileo predicts the birth weight within 2 % in all the categories except in <2500gms (8%). Hadlock predicts the birth weight in <2500gms within 6-7%. All the formulas predicted the birth weight in 2500 – 3000gms category, a major group (n=52) within 8%. Hence prediction of macrosomic fetuses is more accurate with Vintzileo. In prediction of lower weight groups Vintzileo is comparable with Hadlock

*In extreme weight categories error of prediction is less for USG formula in the range of (5.2% – 6.7 %) Vs (9.9 %-10.8%) for clinical methods. Among the Clinical methods **Insler's method is more accurate than Johnson's method***

Bhandary (2004) has also the same conclusion. Standard deviation for Insler is 272 in his study against 253 *in our study*. Mehdizadeh (2000) have concluded that Clinical and USG methods of fetal weight estimation have similar accuracy in normal weight category. This is suitable for places where either USG machines or sonologist are not available.

SUMMARY

- 100 women with singleton term pregnancies in whom fetal anomalies ruled out were selected for study.
- 60% of the patients were in the age group of 20 – 25 years with average year of 24 years. 48% cases were primi gravida and 52% were multi. 58 % delivered vaginally and 42% delivered by LSCS.
- General and obstetric examination was done for all cases including pelvic examination.
- Symphysiofundal height and abdominal circumference at the umbilicus level was measured. From this clinical weight of the fetus was calculated by Johnson and Insler's formula.
- Ultrasound was done for all patients. Parameters – Biparietal diameter, Abdominal Circumference, Fetal Length and Thigh Circumference was measured.
- Estimated fetal weight using Hadlock formula already computed in the machine is taken. Fetal weight using Thigh circumference was calculated from Vintzileo formula.
- The fetal weight measurements by clinical and USG methods are taken within 2 days of delivery. The actual fetal weight was calculated within one hour of delivery in a weighing scale.

- Fetal weight estimated by ultrasound and clinical methods were compared and analyzed by % of error prediction, standard deviation, chi square test and p value.
- Fetal weights in grams were categorized into 4 categories - <2500(9%),2501-3000(51%),3001–3500(32%)and <3500(8%).
- Mean average actual fetal weight was 3042 grams. Standard deviation for Johnson's formula was 232, Insler's formula was 253, Hadlock was 198 and that for Vintzileo was 61.2.
- All the formulas predicted the birth weight in 2500 – 3000gms category (n=51) within 8%.
- Vintzileo predicted the birth weight within 2 % in all the categories except in <2500gms (8%).
- In the above 3500gms group Vintzileo has least error of prediction 2% against 12%to14% for clinical methods.
- Mean difference of weight from actual weight in grams is very less in Vintzileo for all weight categories. 51 for 2500 – 3000group, and 75 for >3500gms group. The % of error is also very less in the order of 1%-2% by Vintzileo.
- Fetal weight estimation by Vintzileo method incorporating thigh circumference was very accurate in all weight categories with very significant p value of <0.0001.

- Particularly in the weight group of above 3500gms the accuracy of Vintzileo formula is great than other formula with prediction error of 1 – 2 % and very much significant p value (0.0001)
- Vintzileo was comparable to Hadlock formula in less than 2500gms categories.
- Insler's formula was more accurate than Johnson's formula in predicting birth weight by clinical methods with a p value of 0.002.
- Both clinical and ultrasound methods predict the birth weights within 7% of the actual birth weights.
- But when there are any growth abnormalities present like macrosomia or intrauterine growth restriction or prematurity then ultrasound methods would give far more precise reports than clinical method.
- Also in 2500 – 3000gms category where majority of cases are present (52%) USG methods are found to be more accurate.

CONCLUSION

- Ø Vintzileo method of measuring thigh circumference and predicting birth weight in all weight categories was more accurate than other ultrasound formula of Hadlock and clinical formulas of Johnson and Insler.
- Ø Vintzileo method is very accurate in predicting birth weight above 3500grams than other formula.
- Ø Ultrasound prediction of birth weight is more accurate than clinical methods in all weight groups particularly when any growth abnormalities are present.
- Ø Among the clinical methods, Insler's formula Using Abdominal girth and Symphysiofundal height was accurate than Johnson's Formula.

BIBLIOGRAPHY

- (1) Irina Burd, Sindhu srinivas et al: Is sonographic assessment of fetal weight influenced by formula selection; J ultrasound medicine 2009; 28; 1019 – 24
- (2). S.Yarkoni, EA Reece, M Wan et al: Intrapartum fetal weight estimation, Comparision of 3 formulae: J ultrasound in Medicine: 1986 V 5:12; 707 – 710.
- (3) S. Raman. Urquhart et al ; Clinical Versus Ultrasound Estimation of Fetal Weight ; Article first published online: 13 FEB 2008; Aus. NZ J of Obs.& Gyn.; V 32; Issue 3, pages 196–199, August 1992
- (4) O.Ayoola,E.O.Orji and associates; Accuracy of various ultrasonographic formula in predicting fetal weight in Anigerian population: Obafemi Awolowo University: Ilorin Nigeria: 2008;06;10;13:37 Tuesday

- (5) Maria Regina Torloni, Nelson Sass et al ; Clinical formulas, mother's opinion and ultrasound in predicting birth weight; Sao Paulo Med. J. vol.126 no.3 São Paulo May 2008
- (6) Hebbar Shripad, N.Varalakshmi.Role of fetal thigh circumference in estimation of birth weight by ultrasound. Journal of Obstetrics and Gynecology of India, 2007 Vol57, No.4. 316 -318.
- (7) Atalie colman,Dushyant maharaj et al: reliability of usg estimation of fetal weight in term singleton pregnancy: Newzealand medical jour.;2006;v119;1241
- (8) George Noumi,Fady Collado – Khoury et al;Clinical and sonographic estimation of fetal weight performed during labor by residents; 2005 AMJ V 192; Issue 5; P 1407 – 1409; 2005.
- (9) Bhandari Aurika A, Pinto patric et al; Comparative study of various methods of fetal weight estimation at term

pregnancy; J obstet. Gynecol 2004 v 54 no 4 july/aug. 336 – 339.

- (10) MWpang, TNleung et al: Validity study of usg fetal wt. estimation in Hongkong Chinese singleton pregnancy; Honkong med. Jour. Jan2004;10;384 -8.
- (11) Baum jonathan d. ; Gussman debra et al;(2002): Clinical and patient estimation of fetal weight vs. ultrasound estimation; Obstetrical and Gynaecological survey; 2002; vol. 57;n°9;p. 558-559
- (12) Mehdizadeh A, Alaghehbandan R et al; Comparison of clinical versus ultrasound estimation of fetal weight.AMJ perinatal 2000;17(5):233-6.
- (13) Ren-IngÂ Liang, Fong-MingÂ Chang,et al; Predicting birth weight by fetal upper-arm volume with use of three-dimensional Ultrasonography; AMJ Obs. & Gyn.;1997; V 177; Issue 3; Pages 632-638.

- (14) Favre and A.M.Bader and associates (1995):Prospective study on fetal weight estimation using limb circumference obtained by three dimensional Ultrasonography; usg Obs&Gyn.:1995;6: 140 -144.
- (15) H.P.S.Sachedev. Low birth weight South Asia. Int. J. DIAB.Dev.Countries (2001) vol.21.
- (16). Meharban singh, Vinod K Paul et al: IAP Book of Pediatrics: Edition3: Page 40 – 41,58 -59:
- (17). Nelson's book of Pediatrics: ed.16:452 – 454.
- (18). Peter.W. Callen; rules of Biometry; Ultrasonography in Obstetrics and Gynecology; edition 5; 232 -240.
- (19). Johnson RW; Calculations in estimating fetal weight. Am J Obs. & Gyn. 1957; 74; 929 -30.
- (20). Insler V, Bernstein D.Rikover.M et al. Estimation of fetal weight in Utero by simple external palpation. Am J Obs. & Gyn. 1967; 98; 292 – 3

- (21). Hadlock FP, Harrist RB, Sharman RS et al. Estimation of fetal weight with the use of head, body and femur measurements - a prospective study. AMJ Obs.& Gyn. 1985; 151 – 333 - 7.
- (22). Vintzileos AM, Campbell WA, Rodis JF et al. Fetal weight estimation formulas with head, abdominal, femur and thigh circumference measurements. AMJ Obs.& Gyn. 1987; 157; 410 – 4.
- (23). Matoo GM, Bhat IA, Shah GN et al. Maximum thigh circumference as an indicator of birth weight. Indian J Maternal child Health 1991;2; 42
- (24). Song TB, Moore TR, Lee JI et al. Birth weight prediction by thigh volume measurement with three dimensional Ultrasonography - Obs.& Gyn. 2002; 96; 157 – 61.
- (25). Lee W, Deter RL, Ebersole JD et al. Birth weight prediction by three dimensional Ultrasonography: Fractional limb volume. J Ultrasound Med 2001; 20: 1283 -92.

PROFORMA

Name: IP No: Unit:
Age: Date of USG estimation
Obstetric Code: Date of Delivery:
LMP: Mode of Delivery:
EDD:

Clinical examination:

Height: cms/ Weight: Kgs/ Pulse rate: / BP: mmhg/

Anemia: anemic / not anemic

Pedal edema: present / not present

Cardiovascular system: Normal / Abnormal

Respiratory system: Normal / Abnormal

Per abdomen: Uterus - weeks, acting / not acting, head mobile / unengaged FH:

Pervaginal: station of head above spines / below spines

Parameters measured:

Symphysio fundal height: cms

Abdominal girth : cms

Biparietal diameter : cms

Abdominal circumference: cms

Femur length: cms

Mid Thigh circumference: cms

FETAL WEIGHT ESTIMATION

Johnson formula	Insler's formula	Hadlock formula	Vintzileo formula	Actual neonatal weight